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Title: Radioactive Source Shielding Strategies

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## Radioactive Source Shielding Strategies

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### **Course Objectives**

- Discuss different options for shielding radioactive sources that will be transported in the Ford Raptor with a stop box during source roundups in Inner Mongolia
- Determine the best shield option based on the isotope and activity of sources loaded into the stop box
- Develop a packaging and shielding plan based on prerecovery information







## **Stop Box Shielding Options**

- No shielding ( $\beta$ ,  $\alpha$  or low activity  $\gamma$  source)
- Small shielded containers (source pigs)
- Shielding that fits into the stop box drum
- Shielding attached to the outer surface of stop box (shadow shield)
- Shielding attached to the vehicle bed (shadow shield)







### Small Shielded Container (5 cm lead)

- Advantages
  - Light weight
  - Maximum shielding effectiveness

### → Disadvantages

- + Small interior dimensions
- Container must have bracing to prevent internal movement or opening during transport













### Shielding that fits into the stop box drum

- Advantages
  - → Allows greater volume for sources
  - → Shield fits in container without bracing
  - → Can be designed with various shield thicknesses based on maximum source activity

### → Disadvantages

 Greater weight than an individual source pig

(example: Pb 5.08 cm 325 kg vs 28 kg)









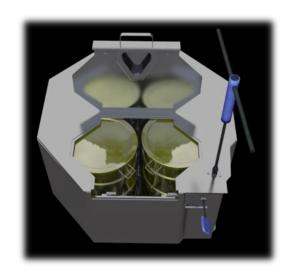


### Shielding attached to the stop box

- Advantages
  - → Allows greatest volume for sources
  - Permanent shielding configuration

### + Disadvantages

- Greater weight than previous configurations
- Only provides shadow shielding
   (example: Pb 5.08 cm 421 kg vs 28 kg)









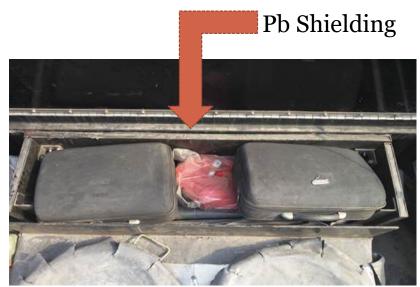


### Shielding attached to the vehicle bed

- **→**Advantages
  - → None shielding effectiveness does not increase

### → Disadvantages

- Greatest weight to vehicle
- Potential damage to vehicle suspension
- + Only provides shadow shield



(example: Pb 5.08 cm 543 kg vs 28 kg)









## Maximum Allowable Shielding Weight

- Vehicle maximum Load Allowed –2040 lbs (927 kg)
- Weight of the Stop Box 470 lbs (214 kg)
- Wt. of passengers 2 passengers (400 lbs) (182 kg)
- Weight Available for Cargo and Shielding (531 kg)







### **Potential Payloads**

## Maximum source activity for normally recovered isotopes

Isotope	Cat 4 Maximum Activity				
	Curies	TBq			
Co-60	< 0.8	< 3.0 E-02			
Cs-137	< 3.0	< 1.0 E-01			
Ir-192	< 2.0	< 8.0 E-02			
Am-241	< 2.0	< 6.0 E-02			







## Method to Calculate Shielding Requirements Prior to Source Roundup

- Based on information obtained prior to the source roundup we can identify source isotopes and activities
- Using the Dose rate Estimate Excel Spreadsheet determine the amount of shielding necessary to maintain drivers dose rate ALARA
- Note that the weight of the shielding and sources should not exceed the 531 kg
- The next slide is an example of the Dose rate Estimate Excel Spreadsheet







### Raptor - Shielding and Dose Rate Estimates for Co-60 and Cs-137

	Raptor 1	ransporte	er - Shie	lding a	nd Dose	Rate Es	timates	for Co-60	and C	s-137
ructions	1. Enter activity a	nd shielding in the	drum into cell .	J,K:23-24 (yell	ow cells).		Calculation by:	: A. Feldman		date:
	2. Green highligh	nted cells will autor	maticall popula	te and			Verified by:	M. Fanning		date:
	display the ca	lculated values.								
					No Sh	ielding *	With S	hielding		
	Isotope	Container Type	Drum Activity (Ci)	Shielding Pb (cm)	Driver Gamma dose rate mSv/hr	Back Seat Gamma dose rate mSv/hr	Driver	Back Seat Gamma dose	Flat Shadow Shield Lead Weight (Kg)	Maximum Drum Lead Weight (Kg)
	Co 60	drum	0.81	2	0.78	1.73	0.16	0.34	213.89	139.06
	Cs 137	drum	1	2	0.23	0.52	0.01	0.03	213.89	139.06
	* No shielding assumes 1.0 cm steel from vehicle and stopbox struct * Buildup has been ignored									
		Gamma Constant	Mass Attenuation Coefficient	Mass Attenuation Coefficient	Density	Density		Inp	ut Values	·
	Isotope	R/hr/Ci @30cm	Iron (cm²/g)	Lead (cm²/g)	Iron (g/cc)	Lead (g/cc)		Isotope	Drum Activity (GBq)	Shielding Pb (cm)
					7.8	11.35	5			
	Co 60	15.19	5.35E-02	7.10E-02			l	Co 60	30	2
	Cs 137							Cs 137	100	









### **Shielding Evaluation**

- The previous slide is based on the maximum activity for a Category 4 Co-60 and Cs-137
- The evaluation assumes a shield thickness of 2 cm of lead
  - The dose rate for the driver would be .16 mSv/hr from the Co-60 source and .01 mSv/hr for a Cs-137 source
- If we assume a shield thickness of 5 cm of lead
  - o The dose rate for the driver would be .01 mSv/hr from the Co-60 source and approximately zero mSv/hr for a Cs-137 source





### **Shielding Effectiveness**

- Shielding effectiveness is based on the type and thickness of the shielding material.
- In all the discussed shielding options the shielding effectiveness is the same.
- The only variable is the amount of shielding required
- The size of the shield is based on the size of the sources





# Comparison of Shielding Options

Options	Pb Thickness/ Weight	Source Type & Activity	Unshielded Dose to Driver	Shielded Dose Rate to Driver
Lead Pig	5 cm 28 kg	Co 60 30 GBq	o.78 mSv/hr	0.01 mSv/hr
Container Shield	5 cm 325 kg	Co 60 30 GBq	o.78 mSv/hr	0.01 mSv/hr
Stop Box Shield	5 cm 421 kg	Co 60 30 GBq	o.78 mSv/hr	0.01 mSv/hr
Vehicle Shield Exceeds Weight Limit	5 cm 543 kg	Co 60 30 GBq	o.78 mSv/hr	0.01 mSv/hr







### **Examples**

On this source roundup we are recovering 25 sources. The recovery will include the following type of sources; Cs-137, Co-60, Am-241

- The source activities will be category IV and V sources
- The total activity for Co-60 sources is 10 GBq
- The total activity for the Cs-137 is 20 GBq
- The high activity sources are 0.2 cm diameter and 1 cm in length
- How much shielding is needed and which shielding configuration is the best for this roundup?

